FINAL REPORT
MAY 2007

REPORT NO. 06-23

TRANSPORTABILITY TESTING OF THE MARINE CORPS LIGHT WEIGHT PRIME MOVER (LWPM) TP-94-01, "TRANSPORTABILITY TESTING PROCEDURES"

Prepared for:

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Commander
Marine Corps Systems Command
Product Group - Ground Transportation and Engineer Systems
PM Motor Transport (PMM 151)
Quantico, VA 22134

DEFENSE AMMUNITION CENTER
VALIDATION ENGINEERING DIVISION
MCALESTER, OKLAHOMA 74501-9053

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REPORT NO. 06-23 **MAY 2007**

TRANSPORTABILITY TESTING OF THE MARINE CORPS LIGHT WEIGHT PRIME MOVER (LWPM) TP-94-01, REV. 2, JUNE 2004, "TRANSPORTABILITY TESTING PROCEDURES"

ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV), was tasked by the Program Manager – Motor Transport, Marine Corps Systems Command, to conduct transportability testing on the Light Weight Prime Mover (LWPM) manufactured by Lockheed Martin. The testing was conducted in accordance with TP-94-01, Revision 2, June 2004 "Transportability Testing Procedures."

The objective of the testing was to evaluate the Light Weight Prime Mover (LWPM) when transportability tested in accordance with TP-94-01, Revision 2, June 2004.

The following observations resulted from the testing of LWPM:

1. The minimal distance between the outside of the pallet and the interior wall of the vehicle made it difficult to engage the strap hooks in the tiedowns.
2. Ratcheting of the straps was difficult due to the ratchet handles being located between the interior wall of the vehicle and the pallets.
3. There may not be adequate storage space on the vehicle for the straps.
4. Due to the limited space between the tie-down rings, a special pallet had to be built to hold the 155MM propelling charges.
5. The area of the deck of the vehicle directly behind the passenger side could potentially be used for storage and securement of boxes of ammunition if tie-down rings on the floor or a securement bar along the wall were added in this area.

6. Prior to the start of testing, both hinges on the tailgate failed. The damaged aluminum hinges were replaced with steel hinges.

7. Removal of the pallets in the forward area of the cargo bed was difficult. Straps had to be wrapped around the pallets and then the pallets had to be slid to the rear of the bed to facilitate their removal by forklift.

8. No excessive movement or damage occurred to the payload, vehicle or tie-down rings as a result of testing.

Throughout testing, the tie-down rings on the LWPM performed adequately. No damage occurred to the tie-down rings or anchors. The LWPM, as currently designed, is adequate for the transport of ammunition.

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REPORT NO. 06-23

Transportability Testing of the Marine Corps Light Weight Prime Mover (LWPM) TP-94-01, Revision 2, June 2004 "Transportability Testing Procedures"

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PART 1 – INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SJMAC-DEV), was tasked by the Program Manager - Motor Transport, Marine Corps Systems Command to conduct transportability testing on the Light Weight Prime Mover (LWPM) manufactured by Lockheed Martin. The testing was conducted in accordance with TP-94-01, Revision 2, June 2004 "Transportability Testing Procedures."

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Joint Munitions Command (JMC), Rock Island, IL. Reference is made to the following:

1. AR 740-1, 15 June 2001, Storage and Supply Activity Operation.

2. OSC-R, 10-23, Mission and Major Functions of U.S. Army Defense Ammunition Center (DAC) 21 Nov 2000.

C. OBJECTIVE. The objective of the testing was to evaluate the Light Weight Prime Mover when transportability tested in accordance with TP-94-01, Revision 2, June 2004.

D. OBSERVATIONS.

1. The minimal distance between the outside of the pallet and the interior wall of the vehicle made it difficult to engage the strap hooks in the tiedowns.

2. Ratcheting of the straps was difficult due to the ratchet handles being located between the interior wall of the vehicle and the pallets.

3. There may not be adequate storage space on the vehicle for the straps.

4. Due to the limited space between the tie-down rings, a special pallet had to be built to hold the 155MM propelling charges.

5. The area of the deck of the vehicle directly behind the passenger side could potentially be used for storage and securement of boxes of ammunition if tie-down rings on the floor or a securement bar along the wall were added in this area.

6. Prior to the start of testing, both hinges on the tailgate failed. The damaged aluminum hinges were replaced with steel hinges.

7. Removal of the pallets in the forward area of the cargo bed was difficult. Straps had to be wrapped around the pallets and then the pallets had to be slid to the rear of the bed to facilitate their removal by forklift.

8. No excessive movement or damage occurred to the payload, vehicle or tie-down rings as a result of testing.

E. CONCLUSIONS. Throughout testing, the tie-down rings on the LWPM performed adequately. No damage occurred to the tie-down rings or anchors. The LWPM, as currently designed, is adequate for the transport of ammunition.

PART 2 - ATTENDEES

ATTENDEE	MAILING ADDRESS
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PART 3 - TEST EQUIPMENT

1. Light Weight Prime Mover
   Truck, Medium, 4 x 4
   Manufactured by Lockheed Martin
   Contract No: M67854-05-D-5032
   Serial Number: 00006
   Tare Weight: 9,560 pounds

2. Railcar DODX 42353
   Manufactured by Thrall Car
   Length: 89 feet – 4 inches
   Empty Weight: 85,000 lbs.

PART 4 - TEST PROCEDURES

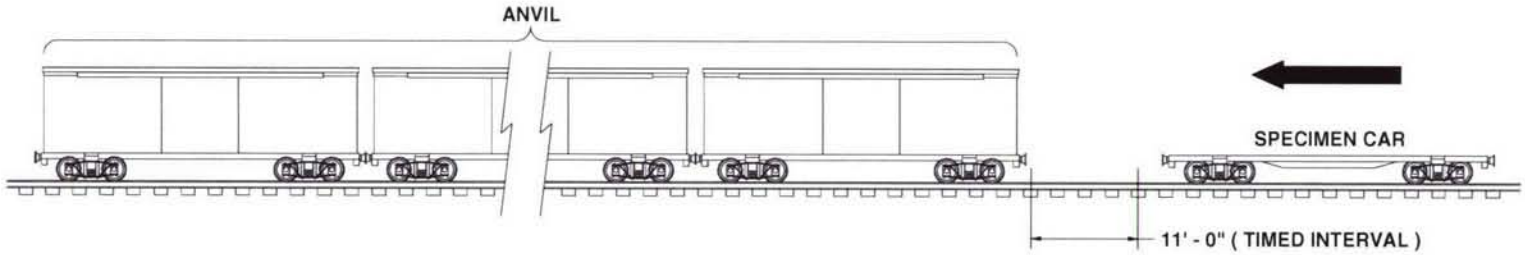
The test procedures outlined in this section were extracted from TP-94-01, "Transportability Testing Procedures," Revision 2, June 2004, for validating tactical vehicles and outloading procedures used for shipping munitions by tactical truck, railcar, and ocean-going vessel.

The rail impact will be conducted with the transport mode secured directly to the railcar. Inert (non-explosive) items were used to build the load. The test loads were prepared using the blocking and bracing procedures proposed for use with munitions (***see Part 6 – Drawings for procedures***). The weight and physical characteristics (weights, physical dimensions, center of gravity, etc.) of the test loads were similar to live (explosive) ammunition.

A. RAIL TEST. RAIL IMPACT TEST METHOD. The test load or vehicle will be secured to a flatcar. The equipment needed to perform the test will include the specimen (hammer) car, four empty railroad cars connected together to serve as the anvil, and a railroad locomotive. The anvil cars will be positioned on a level section of track with air and hand brakes set and with draft gears compressed. The locomotive unit will push the specimen car toward the anvil at a predetermined speed, then disconnect from the specimen car approximately 50 yards away from the anvil cars allowing the specimen car to roll freely along the track until it strikes the anvil. This will constitute an impact. Impacting will be accomplished at speeds of 4, 6, and 8.1 mph in one direction and at a speed of 8.1 mph in the reverse direction. The tolerance for the speeds is plus 0.5 mph, minus 0.5 mph for the 4 mph and 6 mph impacts, and plus 0.5 mph, minus 0 mph for the 8.1 mph impacts. The impact speeds will be determined by using an electronic counter to measure the time for the specimen car to traverse an 11-foot distance immediately prior to contact with the anvil cars (see Figure 1).

ASSOCIATION OF AMERICAN RAILROADS (AAR)

STANDARD TEST PLAN



4 BUFFER CARS (ANVIL)
WITH DRAFT GEAR
COMPRESSED AND AIR BRAKES IN A SET POSITION

ANVIL CAR TOTAL WT. 250,000 LBS (APPROX)

SPECIMEN CAR IS RELEASED BY SWITCH ENGINE TO
ATTAIN: IMPACT NO. 1 @ 4 MPH
IMPACT NO. 2 @ 6 MPH
IMPACT NO. 3 @ 8.1 MPH

THEN THE CAR IS REVERSED AND RELEASED BY SWITCH ENGINE TO ATTAIN:

IMPACT NO. 4 @ 8.1 MPH

Figure 1. Rail Impact Sketch

B. ON/OFF ROAD TEST.

1. HAZARD COURSE. The test load or vehicle will be transported over the 200-foot-long segment of concrete-paved road consisting of two series of railroad ties projecting 6 inches above the level of the road surface. The hazard course will be traversed two times (see Figure 2).

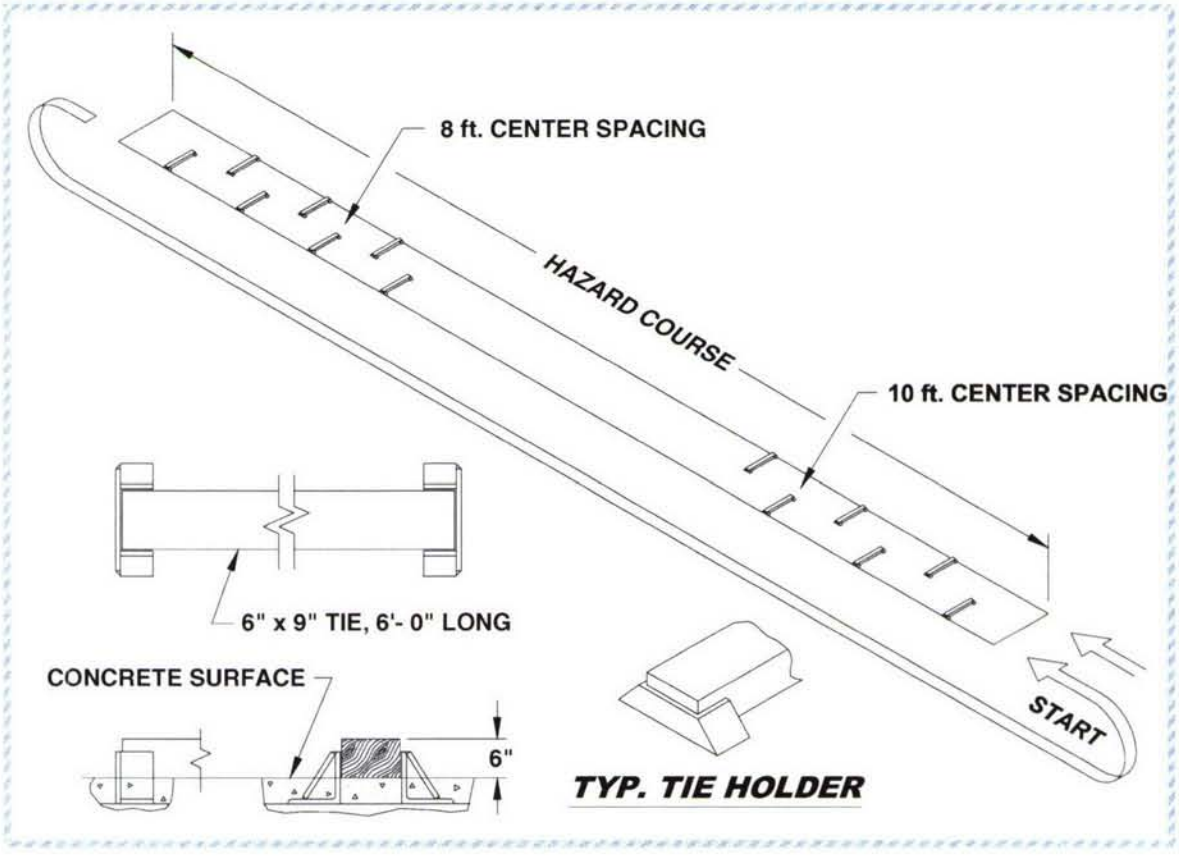


Figure 2. Hazard Course Sketch

a. The first series of 6 ties are spaced on 10-foot centers and alternately positioned on opposite sides of the road centerline for a distance of 50 feet.

b. Following the first series of ties, a paved roadway of 75 feet separates the first and second series of railroad ties.

c. The second series of 7 ties are spaced on 8-foot centers and alternately positioned on opposite sides of the road centerline for a distance of 48 feet.

d. The test load is driven across the hazard course at speeds that will produce the most violent vertical and side-to-side rolling reaction obtainable in traversing the hazard course (approximately 5 mph).

2. ROAD TRIP. The test load or vehicle will be transported for a distance of 30 miles over a combination of roads surfaced with gravel, concrete, and asphalt. The test route will include curves, corners, railroad crossings and stops and starts. The test load or vehicle will travel at the maximum speed for the particular road being traversed, except as limited by legal restrictions.

3. PANIC STOPS. During the road trip, the test load or vehicle will be subjected to three (3) full airbrake stops while traveling in the forward direction and one in the reverse direction while traveling down a 7 percent grade. The first three stops are at 5, 10, and 15 mph while the stop in the reverse direction is approximately 5 mph. This testing will not be required if the Rail Impact Test is performed.

4. WASHBOARD COURSE. The test load or vehicle will be driven over the washboard course at a speed that produces the most violent response in the vertical direction.

C. OCEAN-GOING VESSEL TEST. Shipboard Transportation Simulator (Test Method 5). The Shipboard Transportation Simulator (STS) is used for testing loads in 8-foot-wide by 20-foot-long intermodal freight containers. The specimen shall be positioned onto the STS and securely locked in place using the cam lock at each corner. Using the procedure detailed in the operating instructions, the STS shall begin oscillating at an angle of 30 degrees, plus or minus 2 degrees, either side of vertical center and a frequency of 2 cycles-per-

minute (30 seconds, plus or minus 2 seconds) for a duration of two (2) hours. This frequency shall be observed for apparent defects that could cause a safety hazard. The frequency of oscillation shall then be increased to 4 cycles-per-minute (15 seconds, plus or minus one second per cycle) and the apparatus operated for two (2) hours. If an inspection of the load does not indicate an impending failure, the frequency of oscillation shall be further increased to 5 cycles-per-minute (12 seconds, plus or minus one second per cycle), and the apparatus operated for four (4) hours. The operation does not necessarily have to be continuous; however, no changes or adjustments to the load or load restraints shall be permitted at any time during the test. After once being set in place, the test load (specimen) shall not be removed from the apparatus until the test has been completed or is terminated.

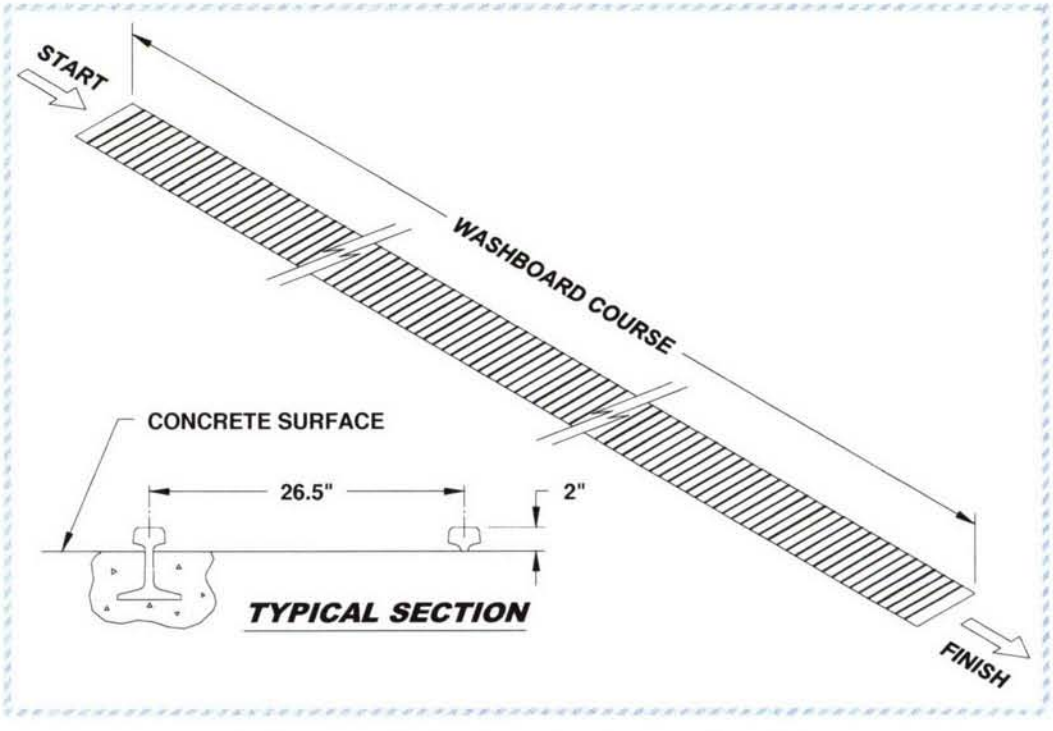


Figure 3. Washboard Course Sketch

PART 5 - TEST RESULTS

5.1

Test Specimen: Light Weight Prime Mover

Payload: 24 complete rounds of 155MM Separate Loading Projectiles.

Testing Date: 11 April 2007

Gross Weight: 13,560 pounds (Including vehicle, ammunition and dunnage).

Payload Weight: 4,000 pounds

Notes:

1. Prior to the start of testing, both hinges on the tailgate failed. The vehicle was delivered with improper aluminum hinges. The aluminum hinges were replaced with the proper steel hinges.

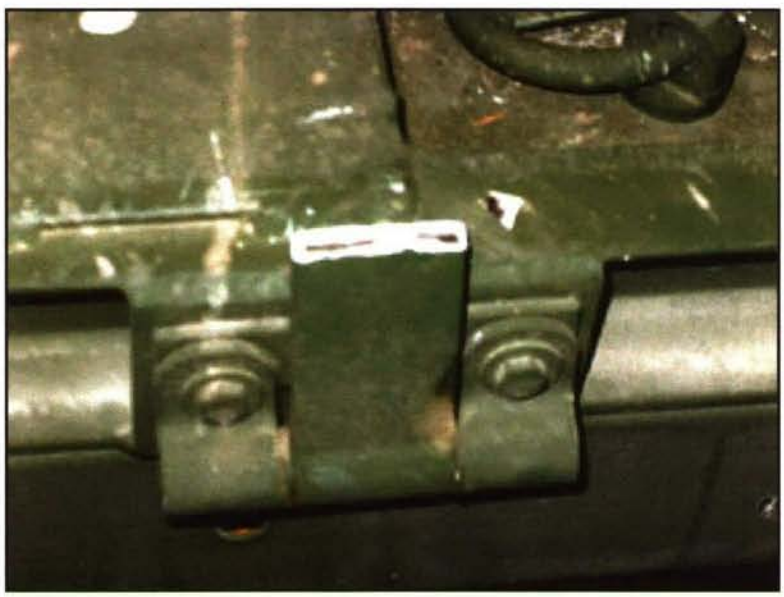


Photo 1. Damaged Tailgate Hinges

2. The minimal distance between the outside of the pallet and the interior wall of the vehicle made it difficult to engage the strap hooks in the tiedowns.

3. Ratcheting of the straps was difficult due to the ratchet handles being located between the interior wall of the vehicle and the pallets.

Photo 2. Limited Access for Straps

4. There may not be adequate storage space on the vehicle for the straps.

5. Due to the limited space between the tie-down rings, a special pallet had to be built to hold the 155MM propelling charges.

6. The area of the deck of the vehicle directly behind the passenger side could potentially be used for storage and securement of boxes of ammunition if tie-down rings on the floor or a securement bar along the wall were added in this area.

A. RAIL TEST.

Photo 3. Rail Impact Testing of the LWPM (Prior to Testing)

Description	Weight
Flatcar Number: DODX 42353	85,000 lbs.
Light Weight Prime Mover	14,980 lbs.
Total Specimen Wt.	99,980 lbs.
Buffer Car (four cars)	257,900 lbs.

Figure 4.

Remarks: Figure 4 lists the test components and weights of the items used during the Rail Impact Tests.

Impact Number	Avg. Velocity (mph)
1	5.2
2	5.5
3	7.9
4	8.3
5	8.3

Figure 5.

Remarks:

1. Figure 5 lists the average speeds of the specimen car immediately prior to impact with the anvil. Impact #5 is the reverse impact.
2. Impact #3 was determined to be a "no test" due to insufficient velocity at impact. The test was repeated.
3. Following Impact #5 the payload compressed 0.5 inches in the direction of impact due to the pallets nesting together.

B. ON/OFF ROAD TESTS.

1. HAZARD COURSE.

Photo 4. Hazard Course Testing of the LWPM

Pass No.	Elapsed Time	Avg. Velocity (mph)
1	21 Seconds	6
2	19 Seconds	7

Figure 6.

Remarks:

1. Figure 6 lists the average speeds of the test load through the Hazard Course.
2. Inspection following each pass did not reveal any damage to the payload, tie-down rings, anchors or LWPM.

2. ROAD TRIP:

Remarks:

1. The Road Trip was conducted between the Road Hazard Course Passes #2 and #3.
2. Inspection following each pass did not reveal any damage to the payload, tie-down rings, anchors or LWPM.
3. The panel at the back of the vehicle cab would not stay closed.

Photo 5. Rear Cab Panel Not Staying Closed

3. **PANIC STOPS:** Testing was not required since the load was rail impact tested.

4. **HAZARD COURSE:**

Pass No.	Elapsed Time	Avg. Velocity (mph)
3	20 Seconds	6
4	21 Seconds	6

Figure 7.

Remarks:

1. Figure 7 lists the average speeds of the test load through the Hazard Course.
2. Inspection following each pass did not reveal any damage to the payload, tie-down rings, anchors or LWPM.

5. **WASHBOARD COURSE:**

Remarks: Inspection following each pass did not reveal any damage to the payload, tie-down rings, anchors or LWPM.

Photo 6. Washboard Course Testing of the LWPM.

C. OBSERVATION: Removal of the pallets in the forward area of the cargo bed was difficult. Straps had to be wrapped around the pallets and then the pallets had to be slid to the rear of the bed to facilitate their removal by forklift.

D. CONCLUSION: Throughout testing, the tie-down rings on the LWPM performed adequately. No damage occurred to the tie-down rings or anchors. The LWPM, as currently designed, is adequate for the transport of ammunition.

PART 6 – DRAWINGS

The following drawing represents the load configuration that was subjected to the test criteria.

TEST SKETCH

LOADING, BRACING, AND TIEDOWN PROCEDURES FOR AMMUNITION ITEMS LOADED ON LIGHT WEIGHT PRIME MOVER

NOTE: THE AMMUNITION TIEDOWN PROCEDURES CONTAINED WITHIN THIS DOCUMENT ARE TYPICAL. THE DEPICTED ITEMS ARE REPRESENTATIVE OF THE VARIOUS TYPES OF AMMUNITION THAT MAY BE RESTRAINED AND TRANSPORTED ON THE LIGHT WEIGHT PRIME MOVER. THESE PROCEDURES WERE USED IN SUPPORT OF THE TRANSPORTABILITY TEST CONDUCTED IN APRIL OF 2007 AT THE DEFENSE AMMUNITION CENTER, MCALESTER, OK.

Prepared during April 2007 by:
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GENERAL NOTES

A. WEB STRAP TIEDOWN ASSEMBLIES MUST BE SECURELY HOOKED INTO ANCHORING DEVICES ON THE TRANSPORTING VEHICLE AND FIRMLY TENSIONED.

B. WHEN LOADING 155MM SLP PALLET UNITS, THEY ARE TO BE POSITIONED SO AS TO ACHIEVE A TIGHT LOAD (TIGHT AGAINST THE FORWARD WALL AND TO EACH OTHER).

C. DUNNAGE LUMBER IS OF NOMINAL SIZE, UNLESS OTHERWISE SPECIFIED. FOR EXAMPLE, 1" X 4" MATERIAL IS ACTUALLY 3/4" THICK BY 3-1/2" WIDE AND 2" X 6" MATERIAL IS ACTUALLY 1-1/2" THICK BY 5-1/2" WIDE.

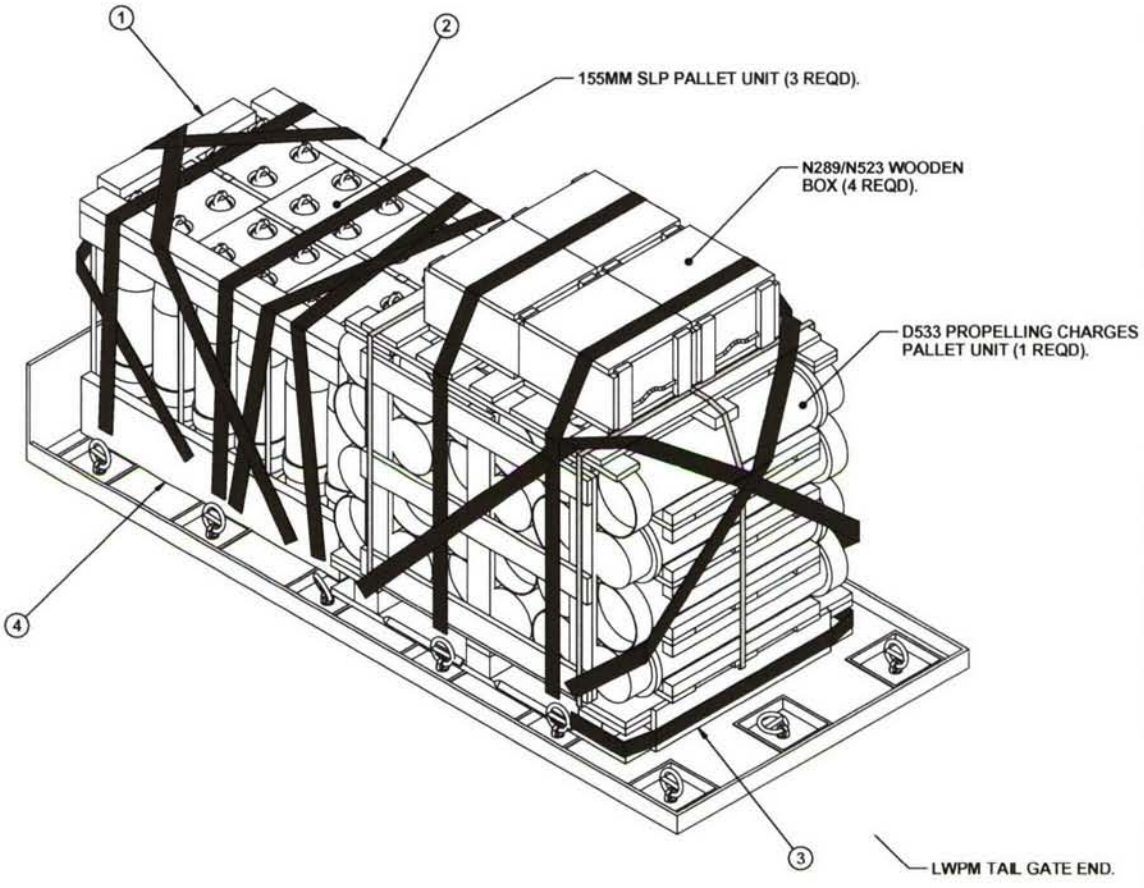
D. A STAGGERED NAILING PATTERN WILL BE USED WHENEVER POSSIBLE WHEN NAILS ARE DRIVEN INTO JOINTS OF DUNNAGE ASSEMBLIES OR WHEN LAMINATING DUNNAGE. ADDITIONALLY, THE NAILING PATTERN FOR AN UPPER PIECE OF LAMINATED DUNNAGE WILL BE ADJUSTED AS REQUIRED SO THAT A NAIL FOR THAT PIECE WILL NOT BE DRIVEN THROUGH, ON TO, OR RIGHT BESIDE A NAIL IN A LOWER PIECE.

E. RECOMMENDED SEQUENTIAL LOADING PROCEDURES:

1. PREFABRICATE ONE END DUNNAGE ASSEMBLY, TWO SIDE DUNNAGE ASSEMBLIES, TWO SIDE EDGE BOARD ASSEMBLIES, AND ONE END EDGE BOARD ASSEMBLIES.
2. LOAD THE 155MM SLP PALLET UNITS, FIRST ONE AGAINST THE FORWARD WALL AND SUBSEQUENT PALLET UNITS AGAINST PROIR PALLET UNITS.
3. LOAD THE PA37 PALLET UNIT TIGHT AGAINST THE LAST 155MM SLP PALLET UNIT.
4. LOAD THE FOUR N289/N523 WOODEN BOXES ON TOP OF THE PA37 PALLET UNIT.
5. INSTALL ALL DUNNAGE ASSEMBLIES IN POSITIONS AS SHOWN ON PAGE 3.
6. INSTALL THE SIX 2" WEB STRAPS THAT CROSS DIRECTLY OVER THE PALLET UNITS, THEN INSTALL THE REAR 2" WEB STRAP AROUND THE END DUNNAGE ASSEMBLY, THEN INSTALL THE FOUR END CROSSING 2" WEB STRAPS (AS SHOWN ON PAGE 3).

MATERIAL SPECIFICATIONS

LUMBER - - - - - - - - :	SEE TM 743-200-1 (DUNNAGE LUMBER) AND VOLUNTARY PRODUCT STANDARD PS 20.
NAILS - - - - - - - - :	ASTM F1667; COMMON STEEL NAIL NLCMS OR NLCMMS).
STRAPPING, STEEL - - :	ASTM D3953; FLAT STRAPPING, TYPE 1, HEAVY DUTY, FINISH A, B (GRADE 2), OR C.
SEAL, STRAP - - - - :	ASTM D3953; CLASS H, FINISH A, B (GRADE 2), OR C, DOUBLE NOTCH TYPE, STYLE I, II, OR IV.
WIRE, CARBON STEEL - :	ASTM A853; ANNEALED AT FINISH, BLACK OXIDE FINISH, 0.0800" DIA, GRADE 1006 OR BETTER.



ISOMETRIC VIEW

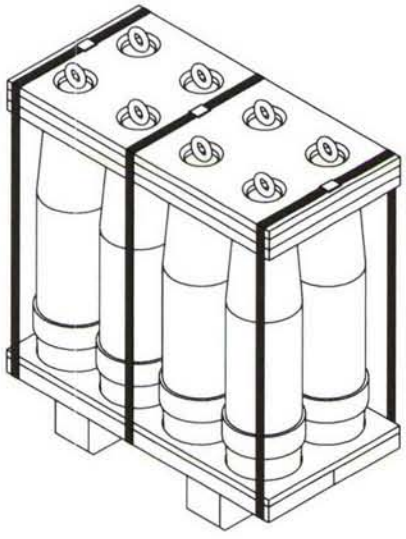
KEY NUMBERS

1. END EDGE BOARD ASSEMBLY (1 REQD). SEE DETAIL ON PAGE 5.
2. SIDE EDGE BOARD ASSEMBLY (2 REQD). SEE DETAIL ON PAGE 5.
3. END DUNNAGE ASSEMBLY (1 REQD). SEE DETAIL ON PAGE 5.
4. SIDE DUNNAGE ASSEMBLY (2 REQD). SEE DETAIL ON PAGE 5.
5. 2-INCH WIDE WEB STRAP ASSEMBLY (11 REQD). PLACE AS SHOWN ABOVE, SECURING THE HOOKS INTO THE TIEDOWN RINGS.

BILL OF MATERIAL		
LUMBER	LINEAR FEET	BOARD FEET
2" X 4" 2" X 8"	20 7	13 9
NAILS	NO. REQD	POUNDS
10d (3")	26	1/2
2" WIDE WEB STRAP - - 11 REQD - - - 60-1/2 LBS		
3/4" PLYWOOD - - - - 1 SQ FT - - - - 2-1/4 LBS		

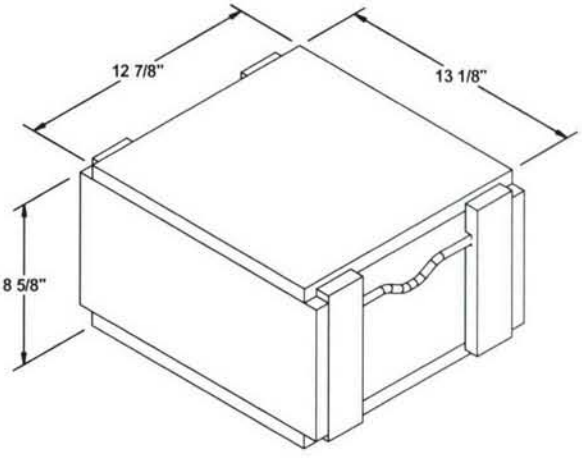
LOAD AS SHOWN

ITEM	QUANTITY	WEIGHT (APPROX)
155MM SLP PALLET UNIT	3	2,355 LBS
PA37 PALLET UNIT	1	1,160 LBS
N289/N523 WOODEN BOX	4	160 LBS
DUNNAGE		107 LBS
TOTAL WEIGHT		3,782 LBS



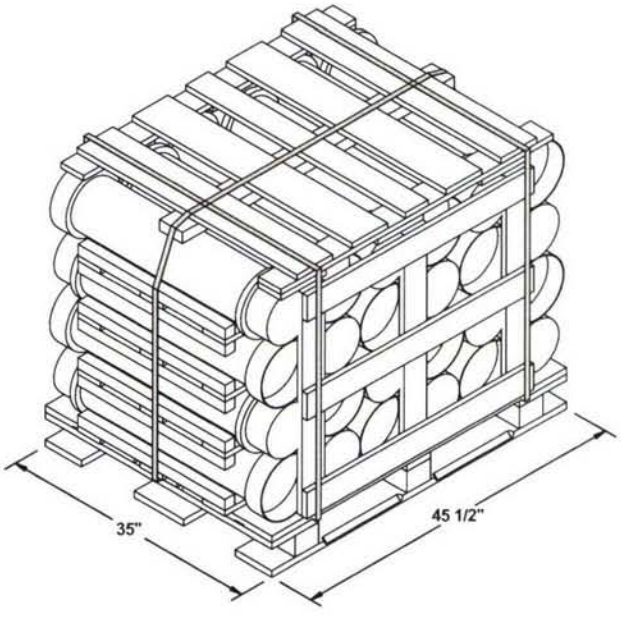
155MM SLP PALLET UNIT

GROSS WEIGHT - - - - - - - - - 785 LBS (APPROX)
CUBE - - - - - - - - - - - - - 6.22 CU FT (APPROX)



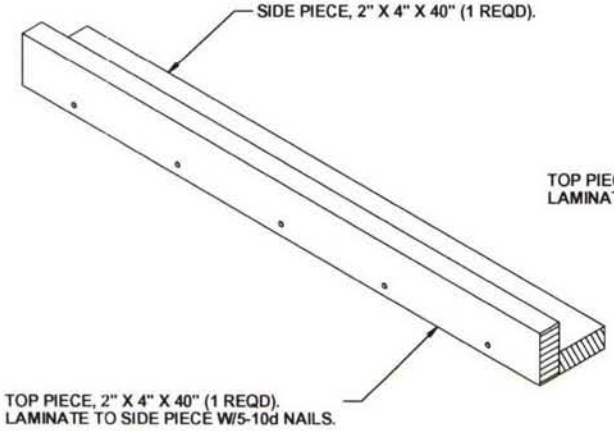
N289/N523 WOODEN BOX

GROSS WEIGHT - - - - - - - - - 40 LBS (APPROX)
CUBE - - - - - - - - - - - - - 0.92 CU FT (APPROX)

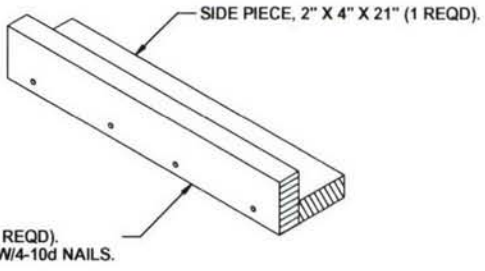


PA37 PALLET UNIT

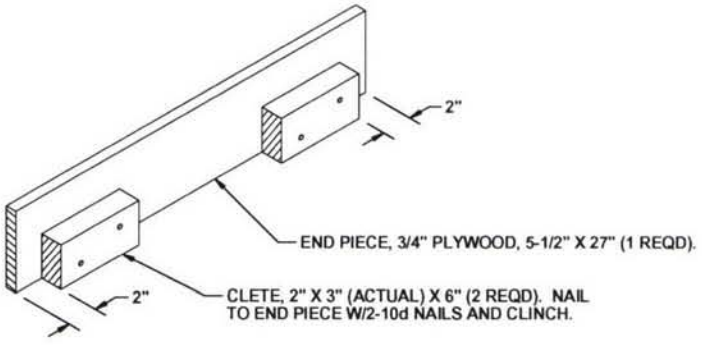
GROSS WEIGHT - - - - - - - - - 1,160 LBS (APPROX)
CUBE - - - - - - - - - - - - - 37.8 CU FT (APPROX)



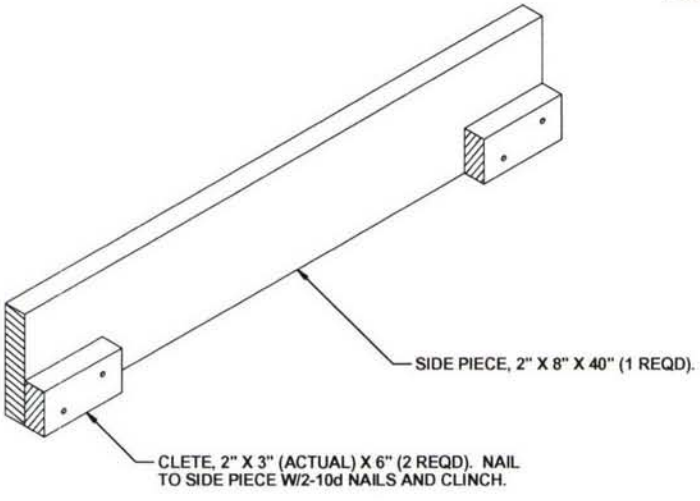
SIDE EDGE BOARD ASSEMBLY



END EDGE BOARD ASSEMBLY



END DUNNAGE ASSEMBLY



SIDE DUNNAGE ASSEMBLY